UNIVERSITY OF CALIFORNIA Berkeley
Transportation Sustainability
RESEARCH CENTER

California Clean Mobility Partnership (2007 AFIP Program)

Presented By:
Timothy Lipman, PhD

ZEV Symposium, Sacramento, CA

September 22, 2009

California Clean Mobility Partnership

Team

- University of California (Berkeley and Irvine)
- California Air Resources Board
- Toyota
  - Toyota Motor Engineering & Manufacturing North America, Inc.
  - Toyota Motor Sales
- South Coast Air Quality Management District
- Bay Area Air Quality Management District
- Southern California Edison
- Horiba, Ltd.

CCMP Overview

- Designed to Be a Three-Year Project (2007-2010)
  - First Two Years Funded by AFIP Program
  - Third Year Funded by Toyota
- Suite of Inter-related Research Activities:
  - Behavioral
  - Technical
  - Economic and Environmental
- Northern and Southern California Research Components

California Clean Mobility Partnership

Goal

Explore the Technical and Market Challenges and Opportunities for:

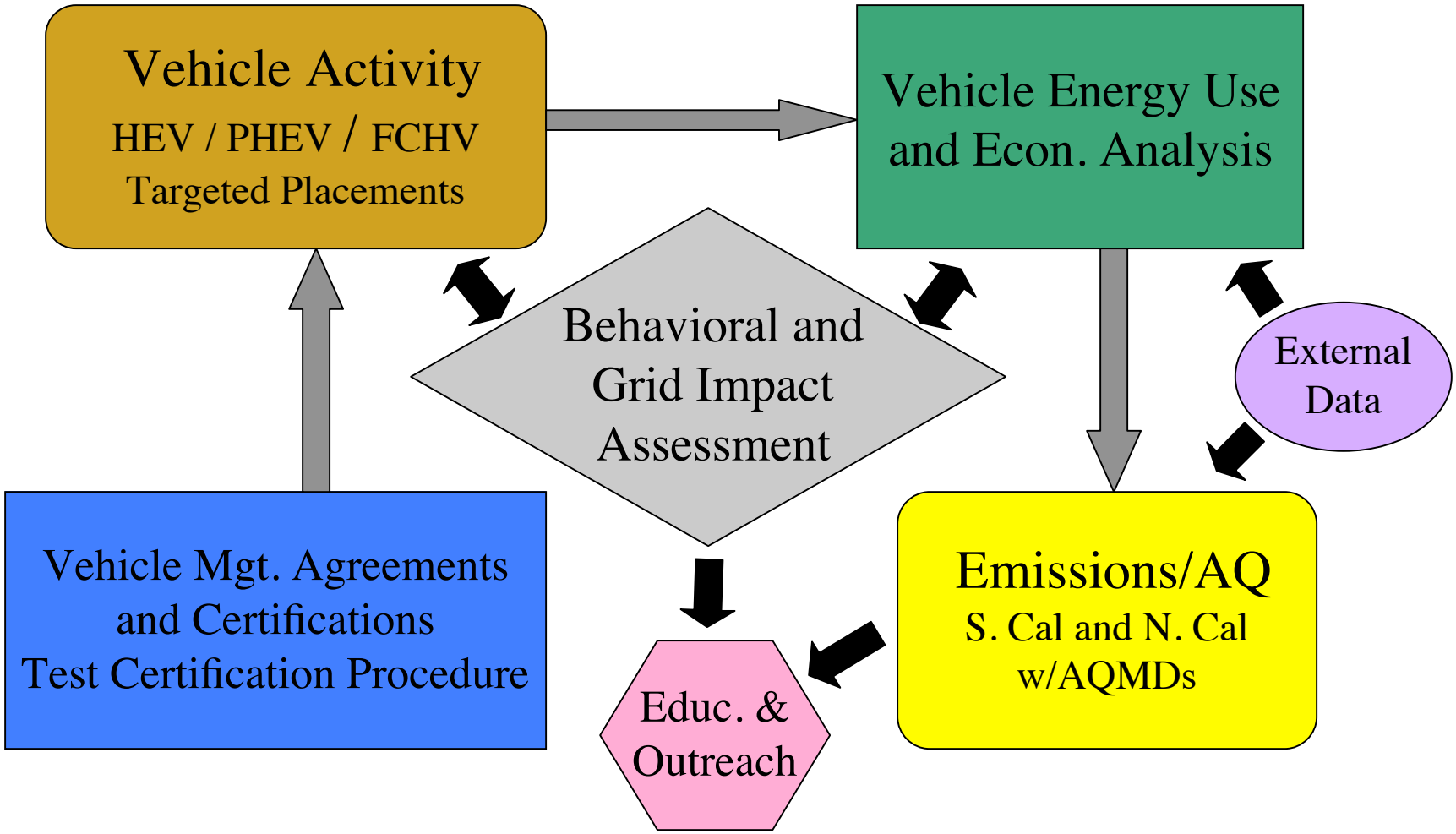
- Plug-In Hybrid Electric Vehicles (PHEVs)
- Fuel Cell Hybrid Vehicles (FCHVs)

Activities

- Real World Vehicle Testing Program (household placements)
- Energy Use and Economic Assessments
- *Utility Grid Impacts (UCI)*
- *Vehicle Testing and Certification Issues (UCI)*
- *Air Quality Impact Assessment (UCI)*

Not reported here

CCMP Project Flow Diagram



CCMP Research Vehicles

CCMP Research Vehicles

- Plug-In Hybrid Electric Prius (PHEV):
  - Modified by Toyota with additional NiMH battery capacity
  - 7-8 mile “all electric range”
  - Blended-mode operation
  - ZEV operation after startup and up to 65 mph with good battery SoC and non-aggressive driving
  - Approx. 4-hour charge time (120V)

CCMP Research Vehicles

- Fuel Cell Hybrid Vehicle advanced (FCHV-adv):
  - Recently demonstrated 68.3 miles per kilogram H_2 (MPGe) and a range of 431 miles during a DOE/SRNL/NREL “real-world” range evaluation
  - Newly designed, high performance fuel cell stack (90 kW) with 25% efficiency boost over previous model
  - Capable of refueling at 10,000 psi (700 bar) for extended range of 350-400+ miles
  - Fuel cell power supplemented by 21 kW of NiMH battery

Study Design - Household Placements

Screening and Placement

- Northern and Southern California placements in parallel
- Company and individual participation
- Consecutive exposure (4 weeks/vehicle)
  - First month: HEV (Prius)
  - Second month: PHEV (Prius)
  - Third month: FCHV-adv (Highlander)
- Drive as normal personal car
- Home and work side charging for PHEVs

Study Design - Household Placements

Placement Analyses

- Study vehicles equipped with GPS and communication technologies to track usage patterns
- Additional “physical” vehicle operational and charging data also collected and analyzed
- Participants complete online survey every 2 weeks
- Design also includes initial focus groups and exit interviews
- Assess household vehicle travel patterns and potential for “early niche” adopters
- Assess charging/fueling behavior

Study Design - Household Placements

Participant Response to Vehicle Attributes:

- Vehicle attributes (range, performance, drivability, acceleration/braking, fueling)
- Comparisons among vehicle types
- Charging and fueling perceptions

Participants Also Asked About:

- Attitudes towards environment
- Willingness to consider innovative technologies
- Demographics

Study Design - Household Placements

Current Status

- Long process for UC Berkeley campus Office of Risk Management and Committee for the Protection of Human Research Subjects approvals
- First time UCB has allowed testing of advanced vehicles with the “general public” (previously confined to UC and other state agency employees)
- First household placements started end of Q1 09, compared with planned Q3 08
- N. California placements are in W. Sacramento with Raley’s Family of Fine Foods and S. California placements are in Irvine with Von Karman Towers

Study Design - Household Placements

Current Status (cont'd)

- Working with companies that are enthusiastic partners -- installing PHEV charging, helping with recruiting participants, etc.
- Eleven participants have completed the study (in 4 N. Cal./2 S. Cal. households) so too early and few to compile and analyze data at this point
- Primary participant is company employee but others in household are allowed
- Expected n = 25-35 total sample of S. and N. California participants by end of study Phase I in June 2010
- Results of data analysis, additional economic and environmental assessments, and expanded project report will be available in Summer 2010

Initial Findings from Household Placements

- There is likely some self-selection for persons that are interested in alt. fuels and/or envt'l issues responding to the solicitation, but participants so far run the gamut from not supportive of alt. fuels to enthusiastic
- Opinions going into the study about alt. fuels do not seem to predict participants' reactions to the vehicles
- Most participants so far knew nothing about alt fuels. -- but some learned as part of the process and some just drove the vehicles without doing any of their own research
- Reactions to plugging-in vary, with some finding it a hassle and "not worth it" while others find it no more difficult or easy than with the Prius

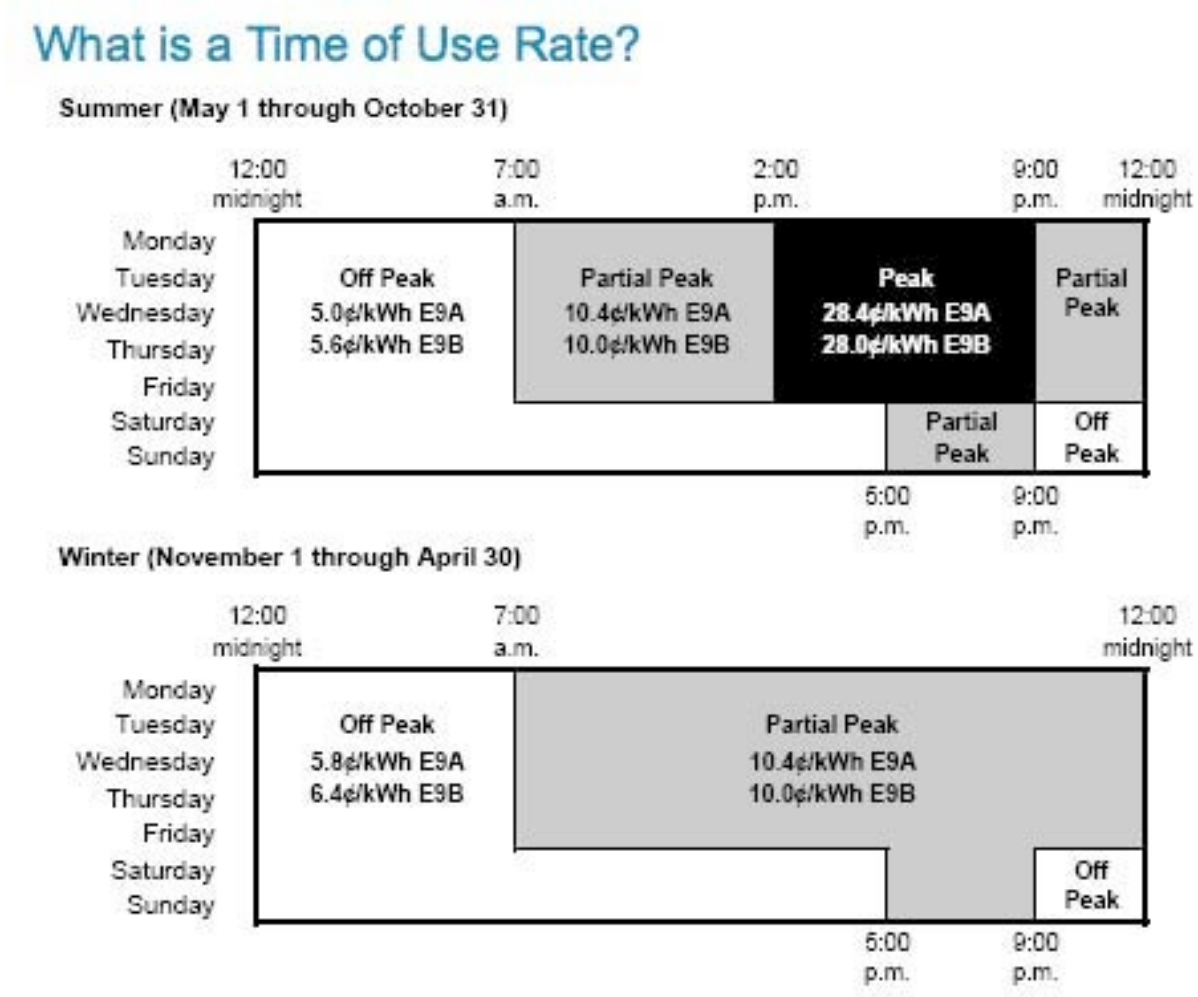
Initial Findings from Household Placements

- All the drivers felt the AER of the prototype PHEV was too short with most noting an AER of 20-25 miles would be more acceptable
- However, these are just initial reactions with the actual “WTP” for additional range being probed in the survey research
- With the PHEV, most everyone took advantage to the toggle to shift in and out of “EV mode” while the battery had charge
- Drivers paid attention to the feedback information
- Drivers felt similarly safe in the PHEV and FCHV-adv from a technology/fuel perspective, but overall felt safer in the larger Highlander
- Most are not clear on if electricity is cheaper or more expensive as a fuel compared to gasoline
- Everyone has been impressed with the performance of the FCHV-adv but not with availability of fueling infrastructure

Energy Use and Economic Analysis

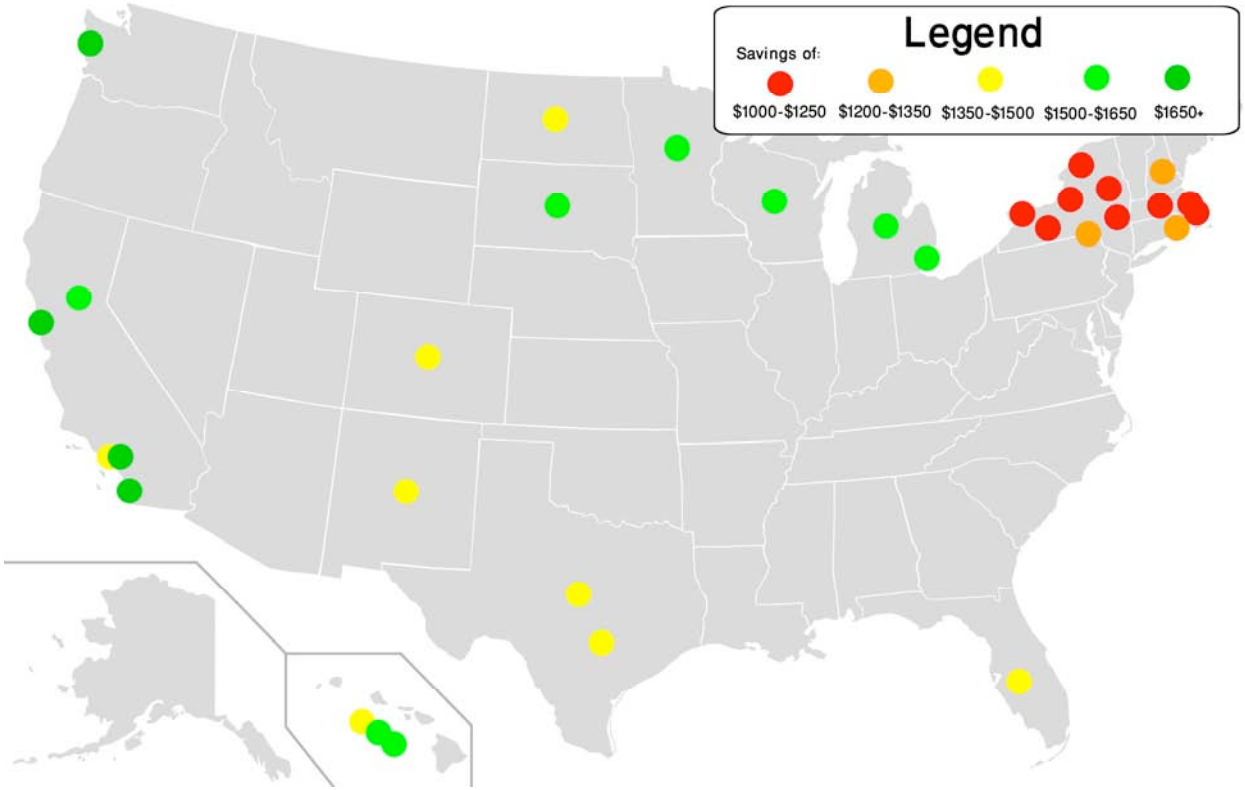
- Analyze Potential Energy Use, Environmental Impacts and Economics of Vehicle Types Based on Household Usage Patterns
- Assess Economics of PHEV Operation
  - Varies considerably by utility service territory and other factors (e.g. electric miles driven, gas prices, etc.)
  - Team developed spreadsheet model to assess based on various regions/utility rates and other variables
  - Begin to explore impacts of economics on driving behavior
- Probe “Willingness-to-Pay” for Different Vehicle Types

Energy Use and Economic Analysis



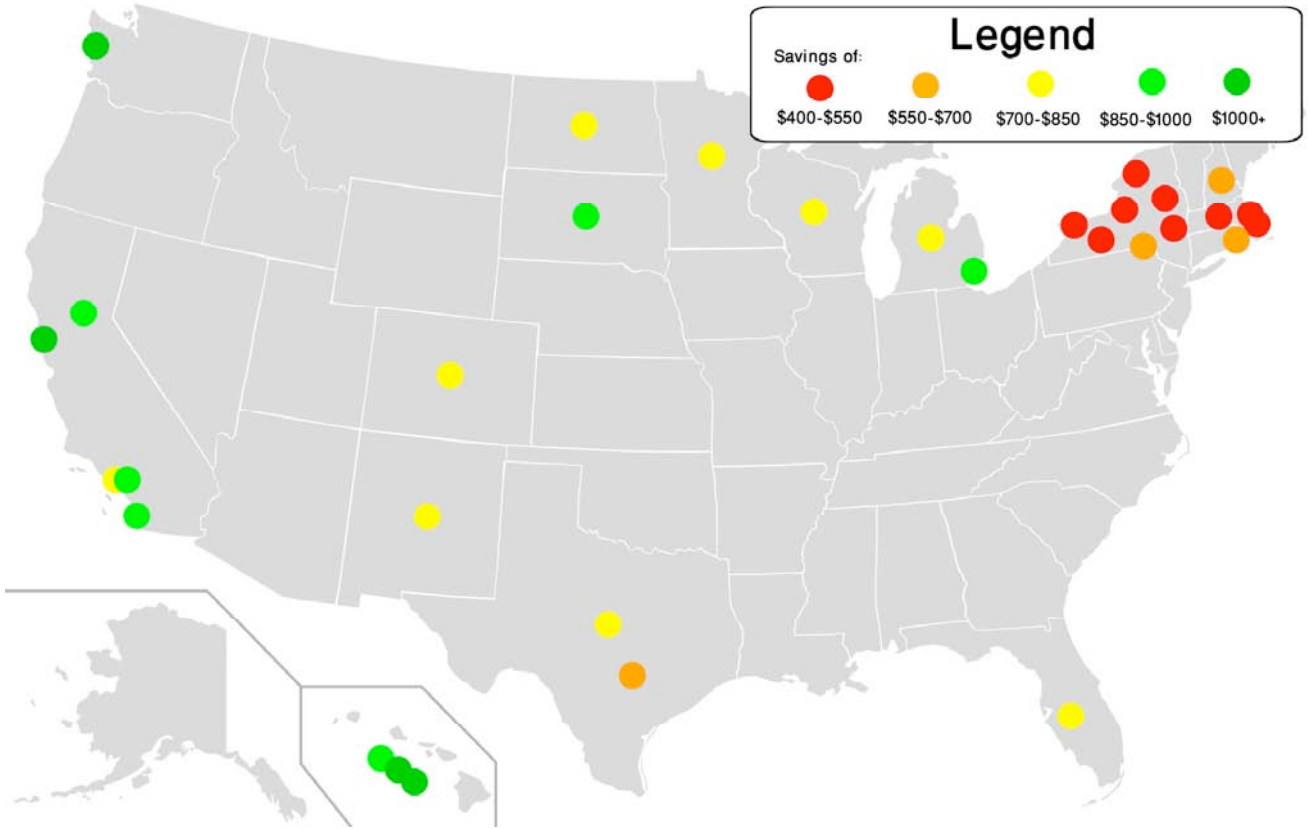
Economic Analysis - PHEV Operating Costs

Analysis based on actual electric utility rate schedules and regional gasoline prices in each service territory. Savings are in $s per year of electricity costs compared with gasoline costs using July 2008 gasoline prices and assuming 10,000 electric miles per year (or its equivalent)



Economic Analysis - PHEV Operating Costs

Now with much lower July 2009 gasoline prices -- still significant savings in some areas but amounts are reduced



Project Next Steps

- Complete Phase I household trials end Q2 2010
- Produce expanded project report that integrates behavioral findings with energy-use and economic assessments and presents analysis of household trial data
- Planning now for Phase II (Q2/3 2010 onward)
- Interest in integrating BEVs into Phase II
- Research limitation is primarily funding to manage placements and conduct analysis and not the availability of interesting vehicles to test

CCMP Team

University of California - Berkeley

- Susan Shaheen (PI)
- Timothy Lipman (Co-PI)
- Rachel Finson
- Brett Williams
- Elliot Martin
- Jeff Lidicker

University of California - Irvine

- Prof. Scott Samuelsen (PI)
- Tim Brown
- Lorin Humphries

Toyota (TEMA and TMS)

- Takehito Yokoo
- Justin Ward
- Vern Francisco
- Jaycie Chitwood
- Craig Scott
- Tatsuaki Yokoyama

www.tsrc.berkeley.edu